The Jupiter Laser Facility – Update

Robert Cauble
JLF Director

NIF/JLF User Group Meeting

February 1-3, 2016

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LLNL-PRES-681298

Jupiter is a multi-platform intermediate-scale facility for HED science, funded by LLNL

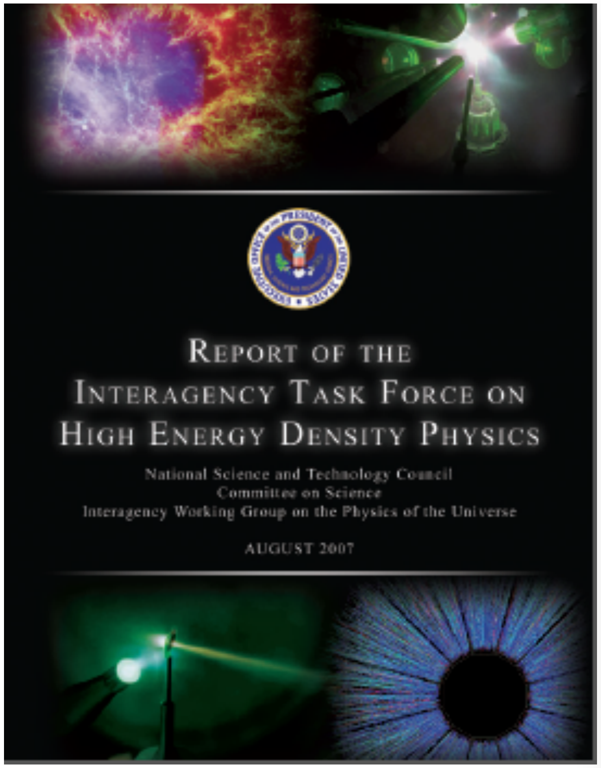
Mission

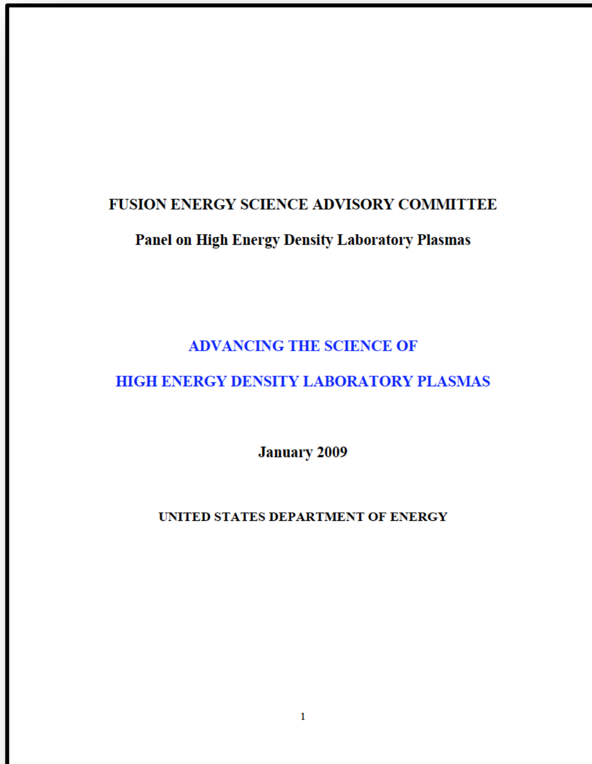
- Expand the frontiers of high energy-density laboratory science
- Support high energy-density science at LLNL in multiple programs
- Support, collaborate with, and expand the broader HED physics community
- Help train and recruit future scientific workforce

Approach

- Office-of-Science-style user facility at which laser time is provided free-of charge and apportioned through an open, competitive peer-review process
- On a scale that provides significantly more laboratory access and greater flexibility than large-scale laser facilities
- With a variety of platforms capable of front-rank HED science for different classes of experiments
- And the infrastructure to safely support multiple users with a range of experience levels

DOE has made recommendations for research in High Energy-Density (HED) science




FUSION ENERGY SCIENCE ADVISORY COMMITTEE

Panel on High Energy Density Laboratory Plasmas

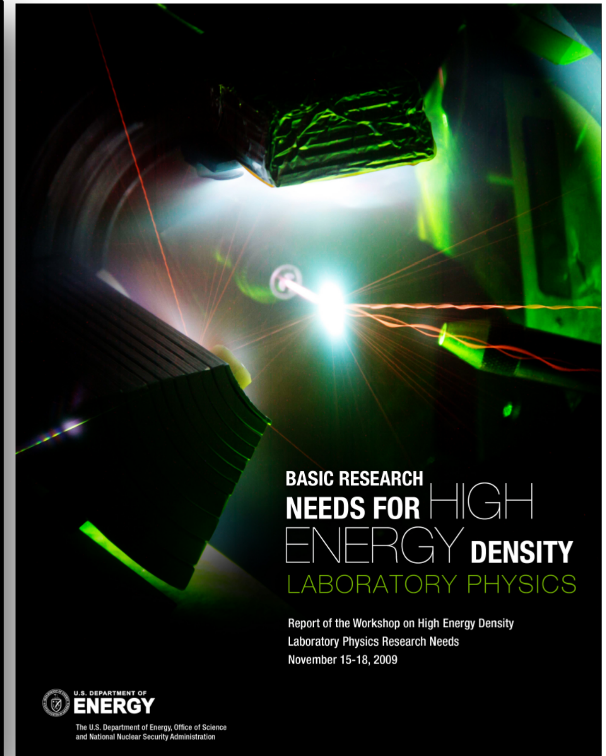
ADVANCING THE SCIENCE OF

HIGH ENERGY DENSITY LABORATORY PLASMAS

January 2009

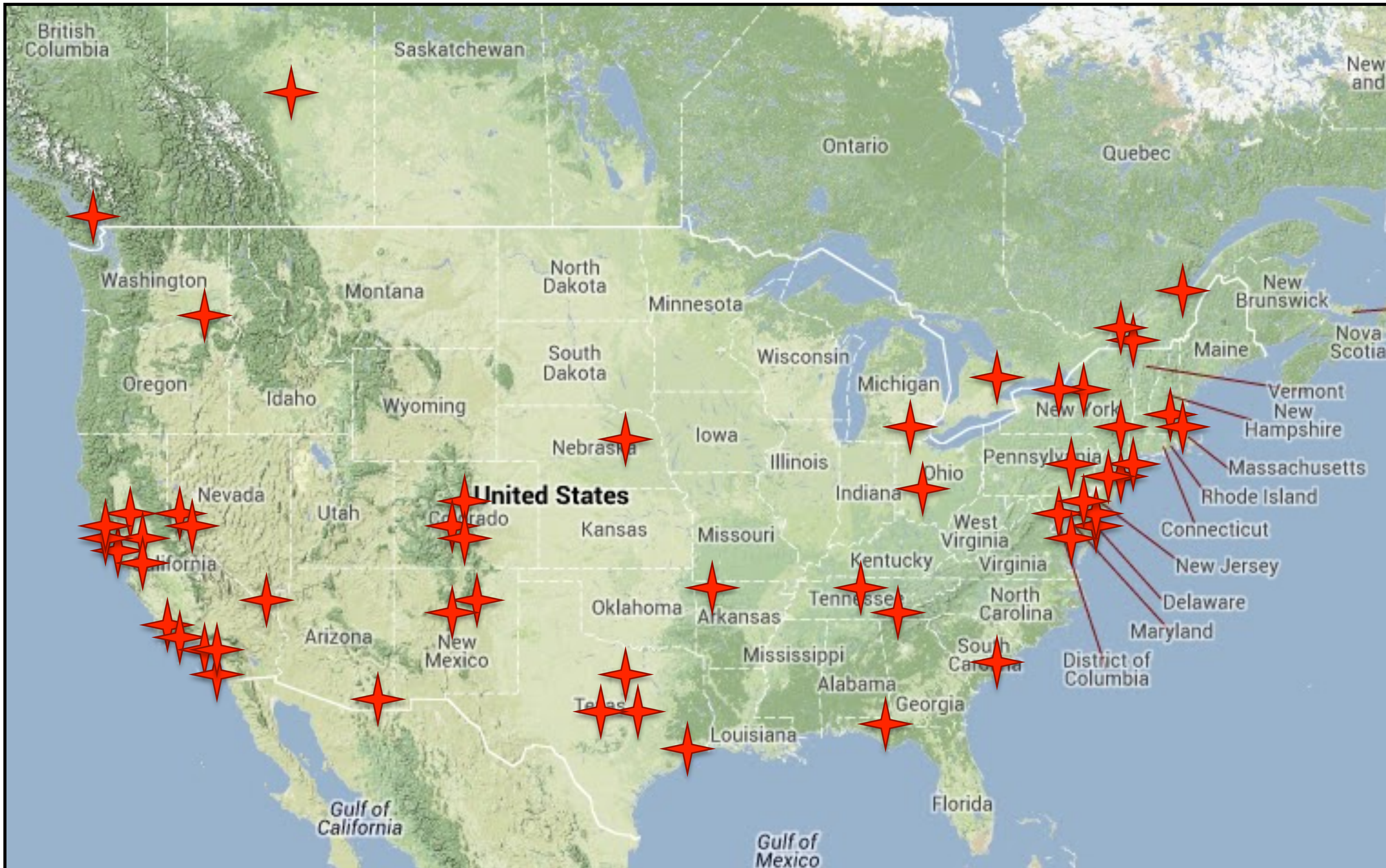
UNITED STATES DEPARTMENT OF ENERGY

1

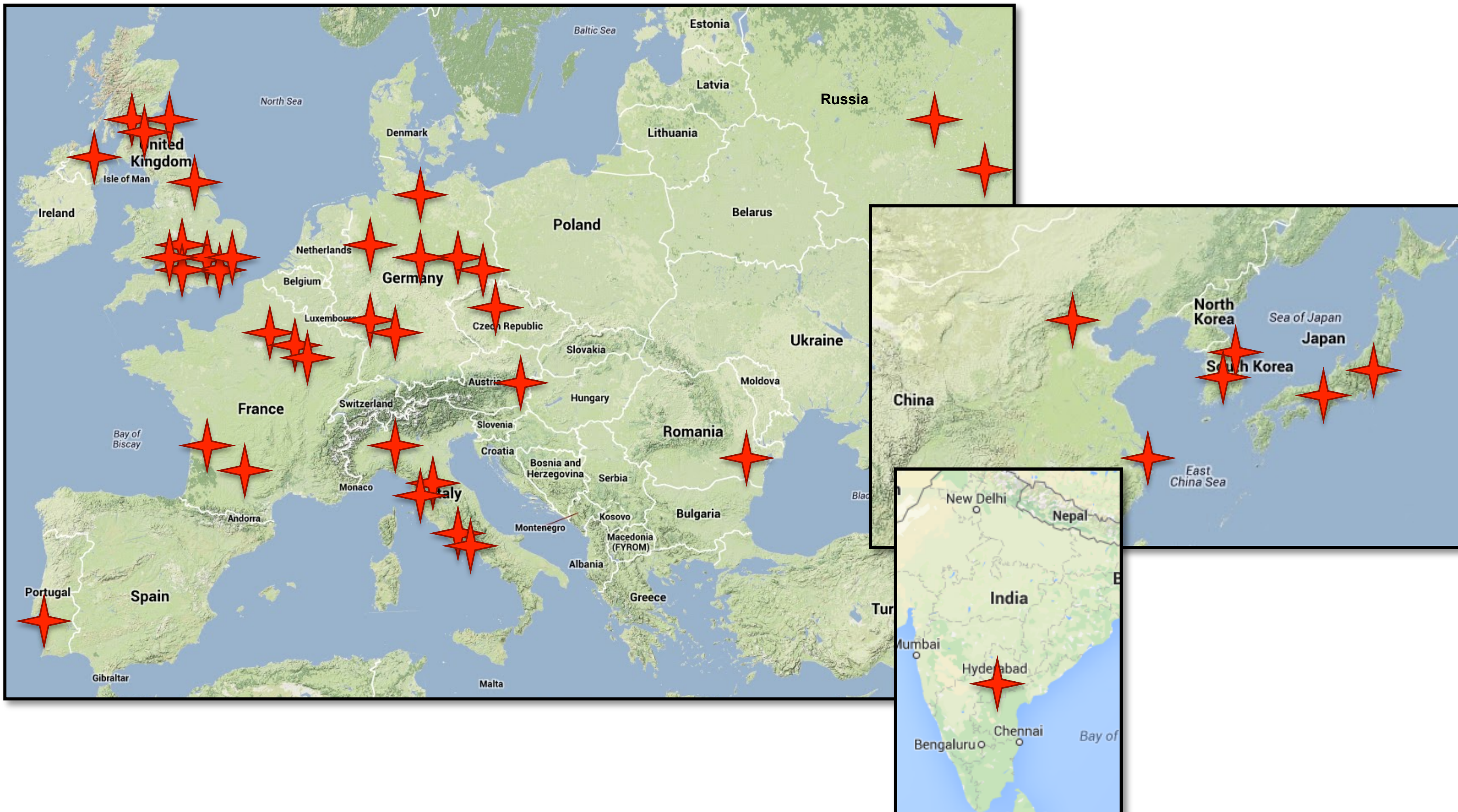


The reports all call for teaching HED science, ***broadening HED research, strengthening academic ties to DOE laboratories, and giving the broader community access to HED experimental facilities***

Jupiter users come from academic institutions and laboratories in the US and Canada,



as well as in Europe and Asia



A number of organizations involved in HED science have active JLF users

LLNL

Engineering
NIF
PLS
WCI

Cal Tech
Colorado St
Columbia
Florida A&M
Harvard
MIT
Ohio State
Princeton
Rice
South Carolina State
Stanford
Texas A&M
U Arizona
U Arkansas
UC-Berkeley
UC-Davis
UCLA
UC-San Diego
UC-Santa Barbara
U Colorado
U Dallas
U Maryland
U Michigan
U Nebraska
U Nevada Las Vegas
U Nevada Reno
U Pennsylvania
U Rochester
U South
U Texas
Vanderbilt
Villanova
Washington State

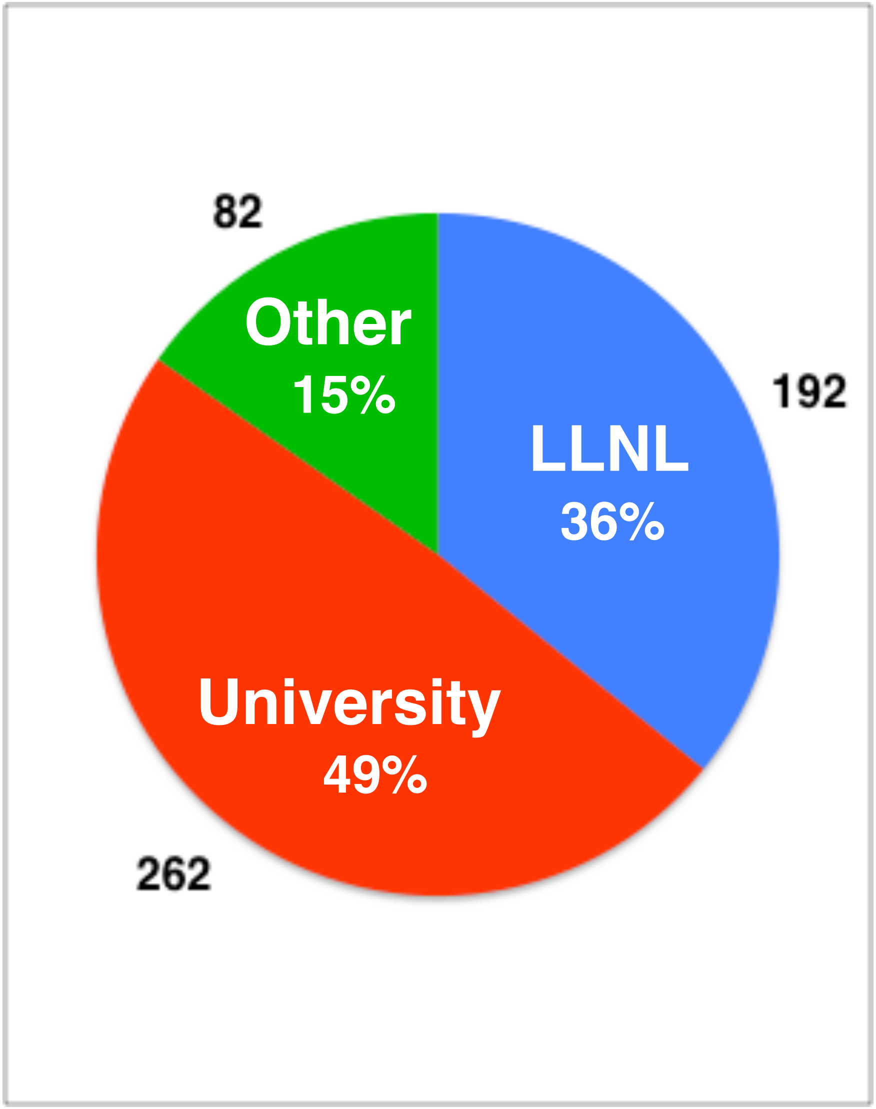
Academy Science Czech
Chinese Academy of Sciences
Ecole Polytechnique
Gwangju IST
Heinrich-Heine U
Imperial College
Indian Inst Tech Hyderabad
INRS - Montreal
IST Lisbon
Leibnitz U
McGill U
Nat Inst Nucl Phys Italy
Osaka U
Queen's U Belfast
Russian Academy of Sciences
Shanghai Jiao Tong U
Tech U Darmstadt
Tech U Dresden
U Alberta
U Bordeaux/CELIA
U British Columbia
U Edinburgh
U Glasgow
U Jena
U Milano
U Oxford
U Paris
U Paris-Sud
U Pisa
U Quebec
U Rome
U Strathclyde
U Toronto
U York
Vienna U Tech

Other Institutions

ARFL
Carnegie Inst
DTRA
Ecopulse
EMC
GA
LANL
LBNL
LLE
NIST
NRL
NSTec
NTF
SLAC

AWE
CEA
CNR/Pisa
DESY
GSI
LNCMI Toulouse
JAEA Japan
KAERI Korea
Kentech
RAL
Rom Inst Phys & NE

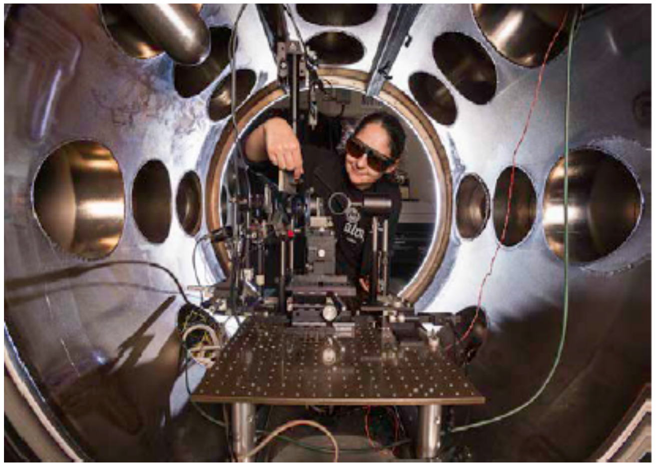
Number of active JLF users is 536



Most JLF PhD students stay in the HED community

There are 134 active student users of JLF

- In the past 36 months, 43 PhDs have been granted to JLF student users
- 36 went on to postdocs or staff positions at labs or universities
  - 9 are now at LLNL
- 3 have recently finished and are interviewing
  - 2/3 at LLNL (and elsewhere)
- 4 went to industry



There were several JLF Phys Rev Letters in 2015

PRL 114, 215001 (2015) PHYSICAL REVIEW LETTERS week ending 29 MAY 2015

Scaling the Yield of Laser-Driven Electron-Positron Jets to Laboratory Astrophysical Applications

Hui Chen,[1] F. Fiuza,[1,2] A. Link,[1] A. Hazi,[1] M. Hill,[3] D. Hoarty,[3] S. James,[3] S. Kerr,[4] D. D. Meyerhofer,[5] J. Myatt,[5] J. Park,[1] Y. Sentoku,[6] and G. J. Williams[1]

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(Received 29 January 2015; published 26 May 2015)

We report new experimental results obtained on three different laser facilities that show directed laser-driven relativistic electron-positron jets with up to 30 times larger yields than previously obtained and a quadratic ($\sim E_L^2$) dependence of the positron yield on the laser energy. This favorable scaling stems from a combination of higher energy electrons due to increased laser intensity and the recirculation of MeV electrons in the mm-thick target. Based on this scaling, first principles simulations predict the possibility of using such electron-positron jets, produced at upcoming high-energy laser facilities, to probe the physics of relativistic collisionless shocks in the laboratory.

DOI: 10.1103/PhysRevLett.114.215001 PACS numbers: 52.38.Ph, 52.59.-f, 52.72.+v

PRL 114, 095004 (2015) PHYSICAL REVIEW LETTERS week ending 6 MARCH 2015

Enhanced Relativistic-Electron-Beam Energy Loss in Warm Dense Aluminum

X. Vaisseau,[1] A. Debayle,[2,3,4] J. J. Honrubia,[2] S. Hulin,[1] A. Morace,[5] Ph. Nicolaï,[1] H. Sawada,[5] B. Vauzour,[1] D. Batani,[1] F. N. Beg,[5] J. R. Davies,[6] R. Fedosejevs,[7] R. J. Gray,[8] G. E. Kemp,[9] S. Kerr,[7] K. Li,[10] A. Link,[11] P. McKenna,[8] H. S. McLean,[11] M. Mo,[7] P. K. Patel,[11] J. Park,[11] J. Peebles,[5] Y. J. Rhee,[12] A. Sorokovikova,[5] V. T. Tikhonchuk,[1] L. Volpe,[1] M. Wei,[13] and J. J. Santos[1,*]

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(Received 6 October 2014; published 4 March 2015)

Energy loss in the transport of a beam of relativistic electrons in warm dense aluminum is measured in the regime of ultrahigh electron beam current density over 2×10^{11} A/cm^2 (time averaged). The samples are heated by shock compression. Comparing to undriven cold solid targets, the roles of the different initial resistivity and of the transient resistivity (upon target heating during electron transport) are directly observable in the experimental data, and are reproduced by a comprehensive set of simulations describing the hydrodynamics of the shock compression and electron beam generation and transport. We measured a 19% increase in electron resistive energy loss in warm dense compared to cold solid samples of identical areal mass.

DOI: 10.1103/PhysRevLett.114.095004 PACS numbers: 52.38.Kd, 52.50.-b, 52.65.-y, 52.70.La

PRL 114, 255001 (2015) PHYSICAL REVIEW LETTERS week ending 26 JUNE 2015

Bursts of Terahertz Radiation from Large-Scale Plasmas Irradiated by Relativistic Picosecond Laser Pulses

G. Q. Liao (廖国前),[1] Y. T. Li (李玉同),[1,4,*] C. Li (李春),[1] L. N. Su (苏鲁宁),[1] Y. Zheng (郑轶),[1] M. Liu (刘梦),[1] W. M. Wang (王伟民),[1,4] Z. D. Hu (胡志丹),[1] W. C. Yan (闫文超),[1] J. Dunn,[2] J. Nilsen,[2] J. Hunter,[2] Y. Liu (刘越),[3] X. Wang (王瑄),[1] L. M. Chen (陈黎明),[1,4] J. L. Ma (马景龙),[1] X. Lu (鲁欣),[1] Z. Jin (金展),[5] R. Kodama (兒玉了祐),[5] Z. M. Sheng (盛政明),[6,3,4,†] and J. Zhang (张杰)[3,4]

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(Received 14 June 2014; revised manuscript received 26 April 2015; published 23 June 2015)

Powerful terahertz (THz) radiation is observed from large-scale underdense preplasmas in front of a solid target irradiated obliquely with picosecond relativistic intense laser pulses. The radiation covers an extremely broad spectrum with about 70% of its energy located in the high frequency regime over 10 THz. The pulse energy of the radiation is found to be above 100 μJ per steradian in the laser specular direction at an optimal preplasma scale length around 40–50 μm. Particle-in-cell simulations indicate that the radiation is mainly produced by linear mode conversion from electron plasma waves, which are excited successively via stimulated Raman scattering instability and self-modulated laser wakefields during the laser propagation in the preplasma. This radiation can be used not only as a powerful source for applications, but also as a unique diagnostic of parametric instabilities of laser propagation in plasmas.

DOI: 10.1103/PhysRevLett.114.255001 PACS numbers: 52.59.Ye, 52.25.Os, 52.38.Kd

PRL 115, 055004 (2015) PHYSICAL REVIEW LETTERS week ending 31 JULY 2015

Formation of Ultrarelativistic Electron Rings from a Laser-Wakefield Accelerator

B. B. Pollock,[1,*] F. S. Tsung,[2] F. Albert,[1] J. L. Shaw,[2] C. E. Clayton,[2] A. Davidson,[2] N. Lemos,[2] K. A. Marsh,[2] A. Pak,[1] J. E. Ralph,[1] W. B. Mori,[2] and C. Joshi[2]

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(Received 23 October 2014; published 31 July 2015)

Ultrarelativistic-energy electron ring structures have been observed from laser-wakefield acceleration experiments in the blowout regime. These electron rings had 170–280 MeV energies with 5%–25% energy spread and ~10 pC of charge and were observed over a range of plasma densities and compositions. Three-dimensional particle-in-cell simulations show that laser intensity enhancement in the wake leads to sheath splitting and the formation of a hollow toroidal pocket in the electron density around the wake behind the first wake period. If the laser propagates over a distance greater than the ideal dephasing length, some of the dephasing electrons in the second period can become trapped within the pocket and form an ultrarelativistic electron ring that propagates in free space over a meter-scale distance upon exiting the plasma. Such a structure acts as a relativistic potential well, which has applications for accelerating positively charged particles such as positrons.

DOI: 10.1103/PhysRevLett.115.055004 PACS numbers: 52.38.Kd, 41.75.Jv, 52.35.Mw

Along with other publications, 18 in total for 2015

PHYSICS OF PLASMAS **22**, 123108 (2015)

Dynamics and structure of self-generated magnetics fields on solids following high contrast, high intensity laser irradiation

B. Albertazzi,[1,2,3] S. N. Chen,[1,4] P. Antici,[2,5] J. Böker,[6] M. Borghesi,[7] J. Breil,[8] V. Dervieux,[1] J. L. Feugeas,[8] L. Lancia,[5] M. Nakatsutsumi,[1] Ph. Nicolaï,[8] L. Romagnagni,[1] R. Shepherd,[9] Y. Sentoku,[10] M. Starodubtsev,[4] M. Swantusch,[6] V. T. Tikhonchuk,[8] O. Willi,[6] E. d'Humières,[8] H. Pépin,[2] and J. Fuchs[1,4,a)]

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(Received 7 July 2015; accepted 11 October 2015; published online 9 December 2015)

The dynamics of self-generated magnetic B-fields produced following the interaction of a high contrast, high intensity ($I > 10^{19}$ W cm^{-2}) laser beam with thin (3 μm thick) solid (Al or Au) targets is investigated experimentally and numerically. Two main sources drive the growth of B-fields on the target surfaces. B-fields are first driven by laser-generated hot electron currents that relax over ~10–20 ps. Over longer timescales, the hydrodynamic expansion of the bulk of the target into vacuum also generates B-field induced by non-collinear gradients of density and temperature. The laser irradiation of the target front side strongly localizes the energy deposition at the target front, in contrast to the target rear side, which is heated by fast electrons over a much larger area. This induces an asymmetry in the hydrodynamic expansion between the front and rear target surfaces, and consequently the associated B-fields are found strongly asymmetric. The sole long-lasting (>30 ps) B-fields are the ones growing on the target front surface, where they remain of extremely high strength (~8–10 MG). These B-fields have been recently put by us in practical use for focusing laser-accelerated protons [B. Albertazzi *et al.*, Rev. Sci. Instrum. **86**, 043502 (2015)]; here we analyze in detail their dynamics and structure. *© 2015 AIP Publishing LLC.* [http://dx.doi.org/10.1063/1.4936095]

PHYSICS OF PLASMAS **22**, 043113 (2015)

Measurements of the energy spectrum of electrons emanating from solid materials irradiated by a picosecond laser

C. A. Di Stefano,[1,a)] C. C. Kuranz,[1] J. F. Seely,[2] A. G. R. Thomas,[1] R. P. Drake,[1] P. A. Keiter,[1] G. J. Williams,[3] J. Park,[3] H. Chen,[3] M. J. MacDonald,[1,4] A. M. Rasmus,[1] W. C. Wan,[1] N. R. Pereira,[5] A. S. Joglekar,[1] A. McKelvey,[1] Z. Zhao,[1] S. R. Klein,[1] G. E. Kemp,[3] L. C. Jarrott,[6] C. M. Krauland,[1,6] J. Peebles,[6] and B. Westover[6]

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In this work, we present the results of experiments observing the properties of the electron stream generated laterally when a laser irradiates a metal. We find that the directionality of the electrons is dependent upon their energies, with the higher-energy tail of the spectrum (~1 MeV and higher) being more narrowly focused. This behavior is likely due to the coupling of the electrons to the electric field of the laser. The experiments are performed by using the Titan laser to irradiate a metal wire, creating the electron stream of interest. These electrons propagate to nearby spectator wires of differing metals, causing them to fluoresce at their characteristic *K*-shell energies. This fluorescence is recorded by a crystal spectrometer. By varying the distances between the wires, we are able to probe the divergence of the electron stream, while by varying the medium through which the electrons propagate (and hence the energy-dependence of electron attenuation), we are able to probe the energy spectrum of the stream. *© 2015 AIP Publishing LLC.* [http://dx.doi.org/10.1063/1.4917325]

PHYSICS OF PLASMAS **22**, 013110 (2015)

On specular reflectivity measurements in high and low-contrast relativistic laser-plasma interactions

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Using both experiment and 2D3V particle-in-cell (PIC) simulations, we describe the use of specular reflectivity measurements to study relativistic ($I\lambda^2 > 10^{18}$ W/cm$^2 \cdot \mu$m^2) laser-plasma interactions for both high and low-contrast 527 *n*m laser pulses on initially solid density aluminum targets. In the context of hot-electron generation, studies typically rely on diagnostics which, more-often-than-not, represent *indirect* processes driven by fast electrons transiting through solid density materials. Specular reflectivity measurements, however, can provide a *direct* measure of the interaction that is highly sensitive to how the EM fields and plasma profiles, critical input parameters for modeling of hot-electron generation, evolve near the interaction region. While the fields of interest occur near the relativistic critical electron density, experimental reflectivity measurements are obtained centimeters away from the interaction region, well after diffraction has fully manifested itself. Using a combination of PIC simulations with experimentally inspired conditions and an analytic, non-paraxial, pulse propagation algorithm, we calculate reflected pulse properties, both near and far from the interaction region, and compare with specular reflectivity measurements. The experiment results and PIC simulations demonstrate that specular reflectivity measurements are an extremely sensitive qualitative, and partially quantitative, indicator of initial laser/target conditions, ionization effects, and other details of intense laser-matter interactions. The techniques described can provide strong constraints on many systems of importance in ultra-intense laser interactions with matter. *© 2015 AIP Publishing LLC.* [http://dx.doi.org/10.1063/1.4906053]

PHYSICS OF PLASMAS **22**, 056705 (2015)

The scaling of electron and positron generation in intense laser-solid interactions[a)]

Hui Chen,[1,b)] A. Link,[1] Y. Sentoku,[2] P. Audebert,[3] F. Fiuza,[1] A. Hazi,[1] R. F. Heeter,[1] M. Hill,[4] L. Hobbs,[4] A. J. Kemp,[1] G. E. Kemp,[1] S. Kerr,[5] D. D. Meyerhofer,[6] J. Myatt,[6] S. R. Nagel,[1] J. Park,[1] R. Tommasini,[1] and G. J. Williams[1]

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(Received 19 February 2015; accepted 30 March 2015; published online 27 May 2015)

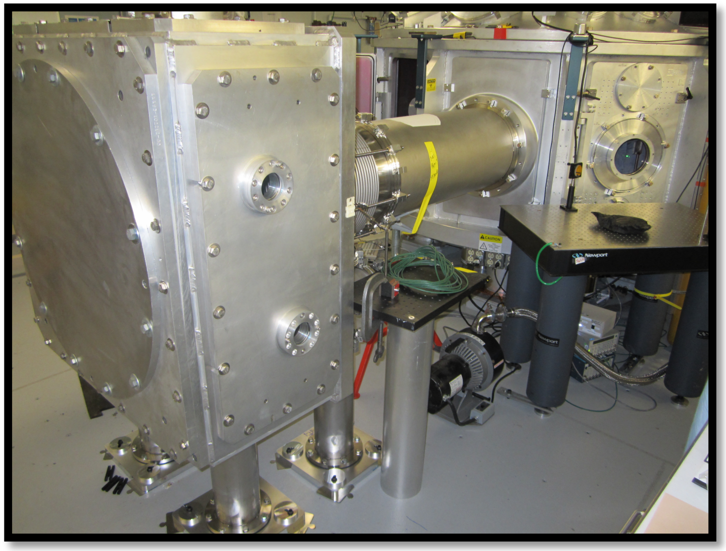
This paper presents experimental scalings of the electrons and positrons produced by intense laser-target interactions at relativistic laser intensities (10^{18}–10^{20} W cm^{-2}). The data were acquired from three short-pulse laser facilities with laser energies ranging from 80 to 1500 J. We found a non-linear ($\approx E_L^2$) scaling of positron yield [Chen *et al.*, Phys. Rev. Lett. **114**, 215001 (2015)] and a linear scaling of electron yield with the laser energy. These scalings are explained by theoretical and numerical analyses. Positron acceleration by the target sheath field is confirmed by the positron energy spectrum, which has a pronounced peak at energies near the sheath potential, as determined by the observed maximum energies of accelerated protons. The parameters of laser-produced electron-positron jets are summarized together with the theoretical energy scaling. The measured energy-squared scaling of relativistic electron-positron jets indicates the possibility to create an astrophysically relevant experimental platform with such jets using multi-kilojoule high intensity lasers currently under construction. *© 2015 AIP Publishing LLC.* [http://dx.doi.org/10.1063/1.4921147]

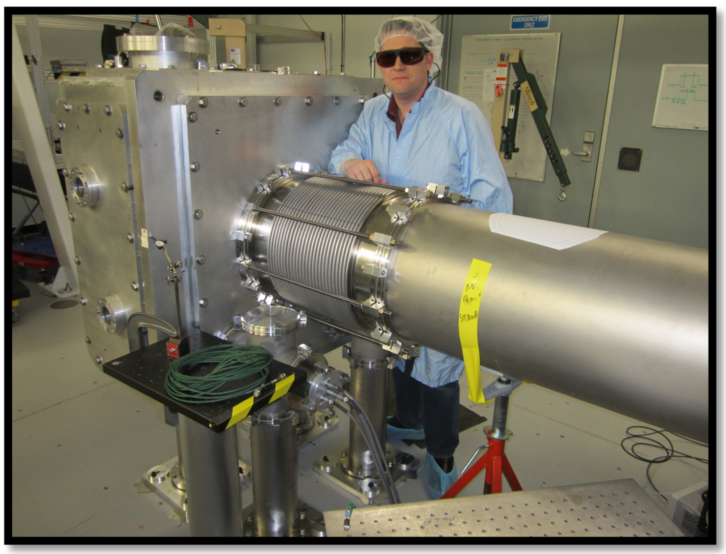
Staff changes

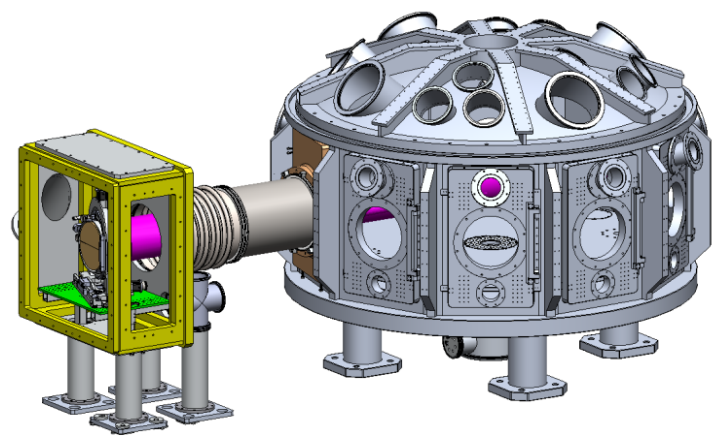
Jim Hunter
Laser Tech

Retired – sort of

We implemented an f/10 OAP on Titan







- A 3-m focal length f/10 final optic was installed (using largely spare parts)
- The first experiment was last winter

Office of Science has stepped in to provide a full aperture green ps beam in Titan

- 1ω ps beam in Titan has a contrast of ~10^{-5}
- JLF has "borrowed" 2ω optics from the decommissioned HELEN laser at AWE
  - sub-aperture so not full energy
  - but contrast of about 10^{-8}
- Experiments that required better contrast opted for green
  - limited success: damaged optics; compressor alignment
- Office of Fusion Energy Sciences – Sean Finnegan – offered to fund replacement optics (2ω conversion crystal, mirrors, coatings) to provide Titan with full-aperture, high-contrast operation
- Optics have long lead-time but have been purchased and will be available later this year
- This is the significant first funding of JLF capabilities from outside LLNL

Where we left it last year

- Stabilize the Facility
- Reinstate 2ω energies on Janus
- Prepare to build out second SP beam on Titan

- Of course it wasn't that simple
  - we did have the Director's investment (FY2015), but that was a fraction of what is needed
  - we needed a plan that all/most of LLNL management would buy into

- Convened a panel of LLNL scientists (summer) following NIF's Strategic Plan exercise (spring) to create a document with options

NIF Strategic Plan includes recommendations that affect JLF

Strategic planning working group:
Lasers and optics for scientific applications

Briefing to SP Integration Team and Senior Management Team

April 23, 2015

1. Maximize utility of NIF, to achieve ignition and explore / probe HED physics at most extreme conditions
2. “Reinvent” smaller-scale scientific lasers to create a rep-rated kJ-class multi-beam facility to accelerate research progress and train the next generation of scientific talent.

   -> Augment and improve JLF (especially TITAN) capability & functionality to provide modern pulse shaping, high reliability, and increased short pulse energy and contrast to enable compression, heating, and probing
3. Establish a dedicated high-energy density science facility with next generation x-ray light sources

Panel met to assess JLF and consider options

- JLF users are a substantial fraction of laser-related experimentalists at LLNL
- Recognition that substantial outside funding is unlikely
- The working group was made up of:
  — Warren Hsing and Bob Cauble, co-chairs
  — Members from earlier study groups: Rip Collins, Nino, Landen, Bruce Remington, Paul Springer
  — “Next gen’s”: Felicie Albert, Dave Bradley, Rick Kraus, Art Pak, Brad Pollock, Steve Ross, Yuan Ping
  — Brent Stuart from JLF
- Goals:
  — Identify and recommend options for a facility that could continue and enhance the mission Jupiter has filled for the next 10-15 years
  — Given investment needed, step back and examine what is best for LLNL
  — Develop some high level needs

High-level requirements for JLF

• First question was whether to continue “something like JLF.” (Yes.)

• Group concurred that a facility that aligned with following criteria would be of significant value for HED science at LLNL. The facility should:

- Provide support for LLNL missions
- Provide an avenue for innovative independent research
- Provide a platform to develop novel scientific ideas, and develop, test, and optimize diagnostics that can be ported or staged to larger facilities
- Provide a user testbed for new technology
- Provide for training, recruitment, and retention of personnel
  - access in time and shot opportunities
  - hands-on
- Provide reliable, reproducible, measured system characteristics
- Be scientifically competitive
- Be flexible in physical configuration, energy selection, pulse shape, spot
- Be realistic, *aka* affordable
- *Be stably, efficiently and safely operated*

Options for intermediate-scale laser-based HED science at LLNL

- **Refurbish JLF**

  - plan includes system diagnostics, improvements to Janus and Titan beamlines, return to full energy, modernize frequency conversion, reliable, reproducible operations, improve beam quality both in time and space, improve pulse-shaping and timing, improve shot-to-shot efficiency, system and experiment data archiving
  - as an improvement, increase shot rate to 20/day
  - no need to increase maximum designed energy in long pulse –- Janus –- beams

- **Add second Titan beamline**

- **Add USP laser capability, in particular high rep-rate**

- **Fit out OSL and B381 infrastructure for high-energy operation**

- **Develop a target area in NIF switchyard at Precision Diagnostic Station**

- **Utilize LCLS lasers at SLAC**
  - existing laser at MEC
  - coming lasers at MEC
  - prospective PW system

JLF refurbishment + 2nd Titan beamline

- **2nd Titan beamline called for by JLF User Group**
- **Would make Titan competitive (few multiple-PW-class facilities)**
- **Two SP beams requested by ~half Titan users (we split the one SP beam)**
  - independent timing
  - independent energy
  - independent placement
- **One beam could generate x-ray or p^+ beam (similar to SACLA)**
  - isochoric heating source
  - e^--e^+ interactions
- **Opens collisionless shock experiments**
- **FI studies (possibly making a resurgence)**

JLF refurbishment + USP

- **LLNL does not have a user-based high-power USP user capability**
- **Only realistic high-rep-rate option ("game changer" in NIF Strategic Plan)**
- **State-of-the-art USP in 10's-of-$M range, not considered realistic**
- **Commercial system, extensible by state-or-the-art amplifiers, may be "affordable"**
- **Sub-ps source development: Could pipe into Titan**

There was a strongly expressed need for a rep-rated USP laser system

- this is the future of laser-based operations, both at XFELs and optical-only facilities
- this is where Europe and Asia are heading
- (hang-up with target availability; various technical solutions in offing)

Is it better to push for such a system or build out another beam of Titan?

Costs: refurbishment, some improvements, and potential upgrades

- **Refurbishment/improvements: $3-5M**
  - Large range depends on acquisition of spare parts (wide variety of optics, pumps, small hardware), operational improvements, possible replacement of pulsed power system, things not *necessarily* needed immediately
  - Janus and Titan only; COMET and Europa are not included

- **Upgrade: Build out second short-pulse beamline: $2M**

- **Upgrade: Rep-rated short-pulse capability: ~$5M**

- **Upgrade: Higher rep rate amplifiers (1 shot/min) in the $30M range**

- **Current funding level would provide ~$0.3M per year**

LLNL FUNDING BEYOND PRESENT MUST BE JUSTIFIED. ANY OPTION THAT REQUIRES FUNDING BEYOND WHAT LLNL CAN PROVIDE REQUIRES A COMPELLING PROGRAMMATIC NEED.

Some refurbishment items are being done now

- **VISAR**. Upgrade to diode-pumped head, new cavity design, elimination of lamp-pumped amplifier, higher efficiency doubling crystal

- **Timing system.** Complete replacement using Greenfield system

- **Titan OPCPA.** Replacement of old lamp-pumped amplifier heads with diode-pumped heads, change from Nd:YLF to Nd:YAG, elimination of phase-conjugate cell

- **Titan beam.** New holographic diagnostic to analyze time- and spatial-dependent field (STRIPED FISH)

- **Operations**. Reconfiguration of 2ω diagnostics path so 1ω diagnostics will always be available

JLF Refurbishment – Laser Bay

- **Diagnostics** ($975k) ($75k GigE cameras, 33-deg mirror images)
  - Spatial, temporal, spectral, and energy diagnostics are needed throughout the system
  - *Includes $560k for seven 8-GHz scopes*
- **Controls upgrade** ($250k) ($80k new controllers)
  - Replace outdated motion control and operational hardware
- **Deformable mirror and wavefront sensor upgrade** ($450k) ($150k wavefront sensor and control software upgrade)
  - Need ability to optimize at focus and pre-correct for amplifier aberrations
- **Long pulse temporal pulse shaping** ($150k)
  - Upgrade Highland hardware and automated pulse shaping
- **Automated system alignment** ($250k)
  - Pointing and centering loops, and pinhole alignment; key to faster shot turnaround
- **Spare optics** ($100k)
  - waveplates, mirrors, lenses

JLF Refurbishment – Janus

- **Front-end stabilization** ($150k) ($75k seed lasers, diode laser controllers, power supplies)
  - Seed laser and regenerative amplifier replacements
- **Replace 2w crystal assemblies** ($150k)
  - 2ω crystals, phase plates
- **Amplifier chain replacements and spares** (~$750k)
  - Optics, rods, disks, flashlamps, rotators
- **Replace phase plates** ($150k)
  - 2ω crystals, phase plates

JLF Improvements - Titan

- **Contrast improvement** ($200k)
  - Short-pulse OPA addition
- **Compressor mirrors** ($250k)
  - Replacements and spares
- **Auxiliary chamber for 2ω optics** ($350k)
  - Remove from compressor chamber, add 2ω diagnostics

Overall JLF Improvements

- **Higher alignment energy** ($80k)
  - Automate waveplates, rotators to provide 4X (1ω) – 16X (2ω) alignment energy
- **Pulsed power replacements and spares** ($600k)
  - Capacitors, solid-state switches, power supplies
- **Lamp and amplifier test stand** ($150k)
  - Need offline test capability

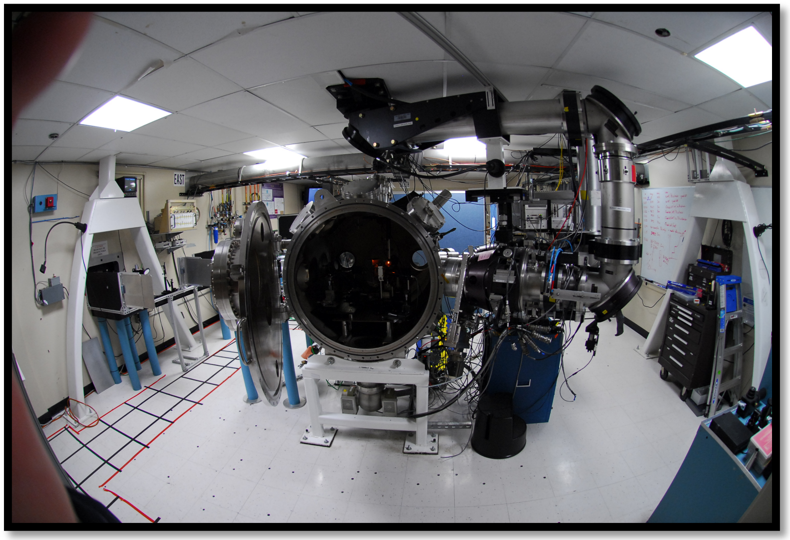
JLF Improvements - *Titan at 1 PW*

- **Temporal pulse shaping** ($150k)
  - Optimization of spectrum and phase for best compression
- **Radial group delay correction** ($100k)
  - Eliminate ~250 fs difference from center to outer edges of beam
- **OPA improvements** ($100k) ($50k crystals, optics, shutter)
  - New crystals, optics and slicer to improve stability

These improvements would make Titan capable of 400 J in 400 fs

CY2016 experiments will investigate a number of HED areas - Janus

- Investigation of momentum transfer and energy deposition for asteroid deflection
- Off-Hugoniot laser-driven compression of silicon-epoxy
- Measuring absorption, x-ray conversion, and hydrodynamic motion in foam-filled hohlraums
- Laboratory simulations of dust destruction by astrophysical shock waves
- Characterization of laser-produced jets in a poloidal B field analogous to Herbig-Haro objects
- Proof-of-principle demonstration of a plasma-based dielectric mirror based on four-wave mixing
- Plasma photonics – Manipulating EM wave polarizations and amplitudes with controlled multi-beam interactions in plasma
- Development of compressed ultrafast photography diagnostic for dynamic laser compression experiments



CY2016 experiments will investigate a number of HED areas - Titan

- Self-aligned hard x-ray source from Raman backscatter in the self-modulated regime of laser wakefield acceleration
- Investigating the impact of ICF strong hohlraum magnetization on LPI and wall plasma heating
- Laser-generated x-rays in an under-dense plasma produced in high-density gas jet mixtures
- Ultra-HED matter using nanostructured targets
- Proton acceleration using a cryogenic hydrogen jet target
- Chromatic focusing and post-acceleration of laser-driven protons
- Proton beam focusing and energy selection by laser-generated magnetic fields
- Ion acceleration from laser-driven electrostatic shocks
- Nanostructure synthesis using laser-accelerated protons

The End